

Article

GIReSiMCo: A Learning Model to Scaffold Students' Science Process Skills and Biology Cognitive Learning Outcomes

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Abstract: The discovery of new knowledge is inseparable from the process of determining whether that applies science process skills (SPS). Science process skills are essential for students to develop science. This study aimed to determine the effect of the GIReSiMCo (Guided Inquiry, Reading, Sharing, Mind Mapping, and Communication) learning model as a new guided inquiry on students' SPS and cognitive learning outcomes. A quasi-experimental research design was applied in biology classrooms at seven senior high schools for one semester. One hundred and twenty-six eleventh-grade students who were interested in mathematics and natural sciences were selected as the research sample. In this study, the application of the GIReSiMCo learning model was compared to that of a guided inquiry model, the Reading Mind Mapping Sharing (RMS) model, and traditional learning models. The two dependent variables are science process skills and cognitive learning outcomes. The data collection instrument for the two variables is in the form of an essay test. The reliability of the instrument test was 0.75 for cognitive learning outcomes, and 0.68 for SPS. The dependent variable data were analyzed using the ANCOVA test. The result showed that the GIReSiMCo learning model had a higher impact on students' cognitive performance and SPS, compared to the traditional learning models. In short, the GIReSiMCo learning model can enhance students' SPS and cognitive learning outcomes. The GIReSiMCo as a student-centered learning model is recommended in Biology learning.

Keywords: biology; guided inquiry; learning outcomes; reading; science process skills



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1. Introduction

1.1. Science Process Skills

Biology is a subject studied in science education that demands a sophisticated learning method to comprehend. A method of studying biology that is relevant to contemporary life has been to involve students in the inquiry process to discover knowledge [1]. Engaging in action means requiring various scientific skills, namely science process skills (SPS) [2]. The application of inquiry learning methods in science learning, including biology, is essential because it has a positive impact on SPS and understanding of science content [3,4]. Inquiry is considered appropriate because this method requires direct student involvement [5] in the investigative process the same as previous scientists [6]. Thus, the learning biology, inquiry learning methods, and SPS are interconnected.

Science process skills are described as physical skills for problem-solving [7], which begins with mental processes in the form of thinking [8,9]. SPS are standard skills needed in investigative actions to discover new knowledge [9,10]. Previous experts [8,10,11] grouped SPS into basic (e.g., observing, classifying, asking, predicting, and communicating) and integrated SPS (e.g., making hypotheses, designing and conducting experiments,

interpreting data, and concluding). In another sense, SPS are similar to scientific reasoning. Several types of skills in SPS (e.g., asking, grouping, hypothesizing, experimenting, and communicating) are also present in scientific reasoning. Scientific reasoning is higher-order, logical, and systematic thinking for problem-solving [12,13]. Khan and Krel [14] explain that science process skills support scientific reasoning for problem-solving.

In science learning, SPS can bridge understanding of scientific concepts [15–17] and supports cognitive learning outcomes [9,18,19]. The application of SPS in learning enables students to conduct scientific investigations to obtain much information [20]. Generally, learning that requires SPS is adjusted to students' cognitive development [7] where the basic SPS are studied at the elementary education level, and integrated SPS are studied at the secondary and higher education levels. This is because the integrated science process skills require more complex reasoning than the basic SPS [9]. The authors view that several types of skills in SPS are related to certain content in science learning, which conforms to the statement of Molefe and Stears [21].

1.2. Guided Inquiry in Science Learning

The global science learning curriculum is designed to prepare students to survive now and in future life [6] by learning through inquiry. Through inquiry learning, students conduct experiments which is a key element to expand knowledge [22]. The importance of conducting inquiry in learning is a serious matter [23] because through inquiry, various 21st-century skills (e.g., creativity, collaboration, and communication) can be developed [24]. Not only science content, but inquiry learning can also develop students' responsible attitudes toward global problems related to science [25] and collaboration [5,24]. The students' ability to solve problems [26], and curiosity [27] can be developed throughout the investigative process in inquiry learning. Cairn [5] stated that inquiry learning gives students the freedom to directly experience the investigative process so that learning becomes meaningful. Inquiry learning is inseparable from natural science learning because students apply SPS in the investigation process.

Several experts describe various types of inquiry [4,6,28], one of which is guided inquiry. The difference between guided inquiry and other types is seen in the teacher's role when conducting the investigation. In the guided inquiry classroom, the teacher plays a key role in facilitating students' investigations [28,29] and in guiding students to determine the observation procedure [6]. The guided inquiry was chosen because the teacher has determined the investigation procedure so that it can save time [29]. The results of students' investigations in guided inquiry leads to known results. Therefore, the failure of student investigations can be minimized [4]. Even though the teacher determines the investigation procedure, the student's creativity is a priority [24].

In the present study, a new learning model based on guided inquiry was developed. Research by Bunterm et al. [3] shows that the guided inquiry model is proven to be better than structured inquiry. Additionally, this model also has an impact on improving students' learning outcomes [4,29,30] and scaffolding students' SPS toward a better direction [4,28]. The stages of guided inquiry are the same as the general inquiry model. Inquiry learning consists of stages as shown in Table 1. However, experts [31,32] present different steps consisting of orientation, conceptualization, investigation, conclusion, and discussion.

In fact, student learning outcomes are unsatisfactory due to several obstacles. Students must understand knowledge by memorizing it [34] so that exam questions are answered by remembering what they have memorized [35]. This method limits students' thinking so that their SPS are not developed. There are many topics to be studied in biology. Therefore, the teacher applies the conventional method, namely, the teacher explains topics, and the students listen [36]. Overcoming this obstacle, we developed a new learning model based on a guided inquiry by adding reading, sharing, and mind mapping activities to it, and we named this model "GIReSiMCo". We believe that these three activities support guided inquiry activities to scaffold students' SPS and cognitive learning outcomes. Reading is important in learning because it stimulates creative thinking skills [37] and serves as a

means to get information [38,39]. Creative thinking is needed to solve problems in the investigation [40], and it is part of the SPS [41]. Experts [37,42] have shown that students' ability to understand the contents of a text gives a strong positive contribution to learning outcomes. Sharing is needed in learning because classroom learning is a social activity, during which students motivate each other [37], exchange ideas [43], and support each other toward successful learning [44]. Biology learning materials for the high school level are plentiful. Therefore, a mind map is needed to make it easier for students to summarize the material and remember it for the future [45]. Research by Hariyadi et al. shows that 38.73% of students' mind maps contributed to the improvement of their learning outcomes [46]. Sometimes students feel bored while studying, so their attention is focused on interesting activities by making a mind map [47]. In addition, mind mapping can also develop creativity [48].

Table 1. Stages of Inquiry Learning [24,33].

Stages	Student Activities
Exploring a phenomenon	Observe a phenomenon or object learning
Making the questions	Make a list of questions and choose one to investigate
Planning the investigation	Design a controlled experiment or investigation to answer the question
Conducting the investigation	Conduct the investigation and collect data
Analyzing the data and evidence	Interpret the data
Constructing new knowledge	Connect new knowledge to the prior knowledge
Communicating new knowledge	Discuss results and conclusions

1.3. GIRESiMCo Learning Model

The GIRESiMCo learning model is a new guided inquiry learning model. This model is designed by combining the guided inquiry learning model developed by Llewellyn [33] with reading, mind mapping, and sharing (RMS) activities as contained in the model, which has been developed by Muhlisin et al.. The inquiry model is different from the RMS model, which can improve critical thinking skills through three main activities, reading, mind mapping, and sharing [45]. The GIRESiMCo model has been validated by experts, and field trials have been conducted to ensure the effectiveness of the model on students' science process skills and cognitive learning outcomes [49].

Reading, sharing, and mind mapping activities are believed to scaffold students' science process skills and cognitive learning outcomes. Reading activities can widen students' knowledge and improve their critical thinking ability [50,51]. In biology learning, the process skills applied by students are activities based on thinking ability [9,35]. Sharing can enhance students' SPS because in small-group discussions, students can freely exchange opinions [43], motivate each other [37], and increase self-confidence [44]. Motivation and self-confidence are intrinsic components that contribute significantly to students' learning outcomes. Through sharing in small groups, students can draw joint conclusions. Creating a mind map is inseparable from reading [48], and formed following how the brain works [52]. Mind mapping has a direct impact on cognitive learning outcomes because it helps students' memories last longer in the brain [46,47]. Mind mapping can increase creativity [48], which is needed in scientific problem-solving and reasoning.

The GIRESiMCo learning model is student-centered. This model was developed by referring to the constructivism learning theory developed by Jean Piaget and the sociocultural theory of Vygotsky. Students construct their knowledge based on experience when they conduct an investigation and social interactions with friends in a group [53]. Science process skills and cognitive learning outcomes are knowledge that is formed from thinking processes. Vygotsky describes knowledge as the result of students' individual and social active involvement in learning [53]. Regular social interaction increases emotional closeness

so that it can support brain work, especially in academic performance [54]. The sequence of learning activities in the GIRESiMCo model can be seen in Table 2.

Table 2. The main activities in GIRESiMCo learning.

Syntax	Learning Activities
Exploring phenomenon	<ul style="list-style-type: none"> ■ The teacher presents phenomena related to learning topics ■ Students directly observe the phenomena using their senses and document their observations
Making the questions	<ul style="list-style-type: none"> ■ Students make critical questions based on their observations on the phenomena ■ Students and teacher decide which questions are considered as important for the investigation
Planning and conducting the investigation	<ul style="list-style-type: none"> ■ The teacher guides students on how to plan the investigation ■ Students perform the investigation based on planning ■ Students gather data for the investigation
Reading for analyzing data	<ul style="list-style-type: none"> ■ Students read critically the reading topic relevant to the investigation ■ Students write down the essential concepts from the reading ■ Students analyze the result observation data
Sharing	<ul style="list-style-type: none"> ■ Teachers assist students in the group discussion ■ Students make tentative conclusions about the investigation
Mind mapping	<ul style="list-style-type: none"> ■ Students make a mind map based on their understanding of the reading and discussion results
Communicating the new knowledge	<ul style="list-style-type: none"> ■ Students classically present the investigation result and argue with each other ■ Teacher and students make a final conclusion about the investigation results

Source: Developed by the author.

1.4. Research Problems

Biology learning applying the GIRESiMCo learning model aims to answer the following questions:

1. Does the GIRESiMCo learning model as a new guided inquiry significantly affect students' science process skills?
2. Does the GIRESiMCo learning model have a significant effect on students' cognitive learning outcomes?

2. Materials and Methods

2.1. Research Design

Learning for one semester was designed in a quasi-experimental form using a non-equivalent pretest-posttest control group design. Different learning models were implemented in four classes. Guided inquiry and the RMS model were applied to two classes who acted as the positive control group, the GIRESiMCo was implemented in one class who acted as the experimental group, and a conventional learning model was used in the other class who acted as the negative control group. The research design is shown in Table 3.

Table 3. Research Design.

Groups	Learning Model	Pretest		Posttest	
Positive control-1	Guided inquiry	SPS	CLO	SPS	CLO
Positive control-2	RMS	SPS	CLO	SPS	CLO
Experiment	GIRESiMCo	SPS	CLO	SPS	CLO
Negative control	Conventional	SPS	CLO	SPS	CLO

Notes: CLO; cognitive learning outcomes.

2.2. Population and Sample

The research population consisted of eleventh-grade students specializing in mathematics and natural sciences in seven schools in the city of Ruteng, East Nusa Tenggara

province, Indonesia. The sample was determined based on certain criteria and was taken randomly. The first criterion is that the school has a laboratory that allows students to do biology practicum. Based on this criterion, four schools containing thirteen groups of students were selected. The second criterion is that the students involved in the research must have an equivalent academic ability. For this second criterion, the thirteen groups of students were tested for academic abilities. The material test was sourced from tenth-grade biology material. The test is constructed in multiple-choice questions, forty items in total. An ANOVA test was conducted to analyze the test data and determine the participants' academic equivalence. The results of the analysis showed that the thirteen groups of students had equivalent academic ability. In the next stage, four classes were randomly selected for treatment, where one class acted as the experimental group (33 students), two classes as the positive control group (32 and 33 students), and one class (28 students) as the negative control group. The total research sample is 126 students.

2.3. Instruments

Instruments were developed based on the needs of the research data. In this study, the instruments consisted of:

a. Learning Tools

The learning tools consist of a syllabus, lesson plans, and worksheets which are designed according to the four learning models, namely guided inquiry, RMS, GReSiMCo, and conventional learning model. Prior to their use, the GReSiMCo learning tools were reviewed by experts.

b. SPS Essay Test

The students' process skills were measured using essay questions. This study did not measure all aspects of students' process skills. There were only seven process skills tested, namely observing, grouping, asking questions, making hypotheses, planning experiments, predicting, and communicating. The seven SPS are a combination of basic and integrated skills, which are adapted to the material and activities of learning biology for one semester. The researchers developed SPS questions (Appendix A) according to the senior high school curriculum applicable in Indonesia by referring to the previous SPS indicators [10,11,55]. Each question number gets a score within a range of 0 to 4 [56]. The seven items of the SPS instrument are shown in Table 4.

Table 4. SPS Instrument Indicators.

Types of SPS	Indicator	Question Number
Observing	Using the senses to gather data related to the observation objects	4
Classifying	Identify similarities and differences between objects and then group them based on certain criteria	2
Questioning	Make questions based on the existing problems	7
Formulating hypotheses	Making a statement that can be tested	6
Planning the experiment	Determine tools and materials to be used and make work plans	3
Predicting	Forecasting the upcoming events is based on previous data and knowledge	5
Communicating	Presenting information about the investigation results	1

Prior to being used to assess students' SPS, the SPS instrument underwent field validation to establish its validity and reliability. The instrument trial was administered

to fifty eleventh-grade students from non-research schools. During field trials, nine SPS question numbers were administered in the form of essay tests. The Pearson Moment Product correlation formula was used to determine validity. The question is declared valid if the correlation value exceeds the alpha (α) value at the 5% level of significance. The analysis revealed that just seven of the nine questions presented were valid. The valid questions were then used to assess students' SPS, while the invalid questions were eliminated. Along with validity, the Cronbach's Alpha test was used to determine the questions' reliability. The reliability analysis revealed that the questions utilized in the study had a reliability coefficient of 0.684. This value is considered quite high [57].

c. Essay Test for Cognitive Learning Outcomes

The test used to measure students' cognitive learning outcomes were developed with reference to the cognitive dimensions according to Anderson and Krathwohl [58], which consist of applying, analyzing, evaluating, and creating. Each question has a score of 0–4 [59]. The test contains 12 essay questions to measure the participants' cognitive performance in biology. The questions were arranged according to the topics learned by the eleventh-grade students for a semester. The questions were field tested to determine their validity and reliability. To determine the validity and reliability of the field test results, the Pearson Product Moment correlation method and Cronbach's alpha were utilized. The study revealed that there were nine valid questions (Appendix B) with a high level of reliability [57] which is 0.75. Only valid questions were used to measure students' cognitive learning outcomes in this study.

2.4. Research Procedures

The fourth treatment groups were taught with different learning models. The experimental class was taught using the GIRESiMCo model, the first positive control class was taught using the guided inquiry learning model, and the negative control class was taught using the conventional learning model. When learning took place, students were grouped into work teams consisting of 4–5 people. The students in the work team have different academic abilities. Learning activities in the four research groups are shown in Table 5.

Conventional learning is the type of learning that teachers frequently employ, whereas creating a mind map is one of the new syntaxes for students at the research school. Thus, prior to the treatment, students were instructed to create a mental map. The author collaborated with the biology teacher at the research school to exchange perspectives on how learning is implemented in their different syntaxes. Although the classrooms employed different learning approaches, they all studied the same topics, namely cell biochemistry, human blood circulation system, plant tissue structures, animal tissues, and human motion system. Along with the same topics, the three groups conducted laboratory experiments on each material in accordance with the applied learning phases. Each subject has a distinct amount of meeting hours assigned to it based on the subject's scope. Thirty meetings were held over the course of one semester, with each meeting lasting 90 min.

The primary data set included information on two dependent variables, SPS and cognitive learning outcomes. Prior to beginning the treatment, each of the four groups took a pretest to collect pretest data and after completing one semester's length of learning, students took a posttest. Along with the primary data, there were supporting data, including information from student workbooks and observation sheets. At the end of each lesson, students' worksheets were gathered. The data on the collected students' worksheets provided qualitative information to supplement the SPS component and cognitive learning outcome data. Thus, data on the two variables can be examined throughout the semester.

2.5. Data Analysis

ANCOVA analysis was conducted to determine whether the GIRESiMCo learning model had a significant effect on students' SPS and cognitive learning outcomes. Kolmogorov Smirnov and Levene tests were carried out to determine the normality and homogeneity of the data as a requirement for the ANCOVA test. The primary data were

declared normally distributed and homogeneous because the significance value was greater than alpha (α) 0.05. The GIRESiMCo learning model was said to affect students' SPS and cognitive learning outcomes because the ANCOVA test results had a significant value lower than the alpha value (α) 0.05. Further analysis using the least significance difference (LSD) test was conducted to determine the smallest significant difference between the four treatment groups.

Table 5. The Four Learning Models in Research.

Learning Models	Learning Stages
Guided Inquiry	<ol style="list-style-type: none"> 1. Exploring phenomenon 2. Making the questions 3. Planning and conducting the investigation 4. Analyzing and interpreting data 5. Constructing new knowledge 6. Communicating the new knowledge
RMS	<ol style="list-style-type: none"> 1. Reading literature 2. Mind mapping 3. Conducting the investigation 4. Sharing the investigation result
GIRESiMCo	<ol style="list-style-type: none"> 1. Exploring phenomenon 2. Making the questions 3. Planning and conducting the investigation 4. Reading for analyzing data 5. Sharing 6. Mind mapping 7. Communicating the new knowledge
Conventional	<ol style="list-style-type: none"> 1. Listening to the teacher's explanation of the topic 2. Making a summary of the learning topic 3. Conducting an investigation 4. Sharing the investigation result 5. Communicating the discuss results

Source: Developed by the author.

3. Results

3.1. Science Process Skills

ANCOVA prerequisite analysis in the form of normality and homogeneity tests was carried out, and the SPS data were normally distributed and homogeneous. The effect of the GIRESiMCo learning model on students' SPS can be seen in Table 6.

Table 6. The Result of ANCOVA Analysis for SPS Data.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3820.640	4	955.160	14.376	0.000
Intercept	26,046.179	1	26,046.179	392.024	0.000
Pretest of SPS	11.697	1	11.697	0.176	0.676
Model	3784.810	3	1261.603	18.989	0.000
Error	8039.270	121	66.440		
Total	599,627.854	126			
Corrected Total	11,859.910	125			

R squared = 0.322 (adjusted R squared = 0.300).

The results of the ANCOVA analysis of SPS in Table 6 show that the significance value of the model ($F = 18.989$) is 0.000, the value is less than 0.005, so it can be concluded that GIRESiMCo learning had a significant effect on students' SPS. The smallest significant

difference between the four groups is known from the results of the LSD test as shown in Table 7.

Table 7. The Result of LSD Analysis for SPS.

Learning Model	Pretest	Posttest	Increase	Critically Corrected	LSD Notation
Conventional	33.57	60.15	26.58	60.084	a
RMS	32.54	66.21	33.67	66.180	b
Guided inquiry	31.34	70.04	38.70	70.070	c
GIReSiMCo	30.65	75.50	44.85	75.555	d

The LSD notation in Table 7 explains that among the four treatment groups, SPS differed from one group to another. Students who were taught using the GIReSiMCo learning model had a higher SPS score than the other three groups, with the conventional group reporting the lowest score.

3.2. Cognitive Learning Outcomes

Similarly, data on students' cognitive learning outcomes data were also normally distributed and homogeneous. The effect of the GIReSiMCo learning model on students' cognitive learning outcomes can be seen from the results of the ANCOVA analysis shown in Table 8.

Table 8. The Result of ANCOVA Analysis for Cognitive Learning Outcomes.

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	9335.259	4	2333.815	20.782	0.000
Intercept	57,566.987	1	57,566.987	512.631	0.000
Pretest_cognitivlearningoutcomes	7.485	1	7.485	0.067	0.797
Model	9284.202	3	3094.734	27.558	0.000
Error	13,587.961	121	112.297		
Total	518,239.427	126			
Corrected Total	22,923.221	125			

R squared = 0.407 (Adjusted R squared = 0.388).

Table 8 shows $F = 27.558$ with a significance value of $0.000 < 0.005$. It proved that the GIReSiMCo learning model as a new inquiry model had a significant effect on cognitive learning outcomes. To find out more about the differences between the four learning models, the LSD test explains it in detail in Table 9.

Table 9. The Result of LSD Analysis for Cognitive Learning Outcomes.

Learning Model	Pretest	Posttest	Increase	Critically Corrected	LSD Notation
Conventional	27.38	49.80	22.42	49.828	a
RMS	25.78	60.85	35.07	60.837	b
Guided inquiry	26.26	63.72	37.46	63.719	b
GIReSiMCo	26.01	74.41	48.4	74.403	c

Based on the data in Table 9, especially in the column "increase" and LSD notation, it was known that the GIReSiMCo learning model in addition to having a higher improvement value, is also different from the other three models. The RMS and guided inquiry learning models reported the same LSD notation, meaning that there was no difference in cognitive learning outcomes between the two models, but these two models are different from conventional learning and GIReSiMCo learning.

The statistical analyses showed that the GIRESiMCo learning model was effective in scaffolding students' SPS and cognitive learning outcomes. This model was different and has a higher score compared to all the comparison models. Meanwhile, the conventional group reported the lowest score of all treatment groups (the GIRESiMCo learning model, the guided inquiry model, and the RMS model) on the two variables. The guided inquiry learning model was different from the three models in terms of improving students' SPS but was similar to the RMS model in terms of enhancing students' cognitive learning outcomes.

4. Discussion

The data in Table 7 shows that the GIRESiMCo learning as a new inquiry model is different from other learning models in terms of scaffolding students' SPS. The LSD notations in Table 7 also indicate that the four treatment groups achieved different scores on SPS, where the GIRESiMCo group reported the highest score improvement and the conventional group obtained the lowest increase. Process skills are skills that can be trained for students. Therefore, practicing SPS for a semester can have a positive impact on students' SPS scores.

Table 9 also shows that the GIRESiMCo learning model can scaffold students' cognitive learning outcomes. In this case, cognitive learning outcomes of students in the GIRESiMCo were higher than those of students in other groups. Although the four groups of students experienced an increase in scores after one semester, the LSD notation showed that there was no significant difference between the guided inquiry group and the RMS group. Cognitive outcomes performance increased the least in the conventional group.

The conventional group experienced an increase in science process skills and cognitive learning outcomes after treatment, but the increase was much lower than the increase in SPS and cognitive performance in other treatment groups (GIRESiMCo model, guided inquiry, and RMS). The same finding was also found in previous studies, in which the conventional group had the lowest scores in science learning compared to other treatment groups [28,29,32]. The most prominent aspect of learning in the traditional classroom is the teacher's role as the main actor in learning. This role constrains students' potential to develop, particularly in science process skills. The old method, which needs students to listen to the teacher explain, create summaries, then memorize summaries, is considered inefficient, as students' recall of the topics they have read would fade quickly.

The students' SPS and cognitive learning outcomes scores in the guided inquiry group were found to be higher compared to the RMS and the conventional model. The findings in this study support the previous research that students who are directly involved in inquiry can have their learning experiences permanently stored in long-term memory [60], scaffold the students' cognitive structures and develop analytic thinking ability [35] so that cognitive learning outcomes [3,4,29], and SPS [61,62], are increased. However, the results of this study indicate that the guided inquiry model has a lower score than the GIRESiMCo model for the SPS and cognitive learning outcomes variables.

The rationale for understanding why the GIRESiMCo model can improve students' SPS and cognitive learning outcomes is that the learning model combines guided inquiry with reading, sharing, and mind mapping activities. Learning with GIRESiMCo demands students to participate actively in the learning process by utilizing a variety of body parts and modes of learning. Students engage their five senses when watching and exploring events, expressing their viewpoints while discussing and communicating, and exhibiting their artistic abilities while creating mind maps. Reading, sharing, and mind mapping activities combined into guided inquiry improved SPS and students' cognitive learning outcomes in this study.

Reading activities were carried out when students finished their investigation and had not found conclusions. The reading done in this study is a critical reading from scientific reference. This activity is done with the main aim to be able to analyze the investigation data. While reading, students jot down key points from these scientific references. The brief notes assist students in connecting reading knowledge to investigations. Because not

all answers to research issues may be discovered directly through examination, reading is required. Reading can help reinforce the investigation's findings. In addition, reading helps pupils develop their ability to think critically and creatively [50]. Science process skills are necessary for making inferences in reading tasks. Students who can think critically and creatively can reach good conclusions. Both abilities are classified as higher-order thinking abilities in Bloom's Cognitive Dimensions [16]. Critical and creative thinking enables students to make connections between the material gleaned through investigations and the information gleaned from reading, allowing students to draw conclusions more easily from investigations. The findings of this study corroborate those of Irwanto [35] and Özgelen [9], who concluded that the science process skills employed by students when learning biology correspond to their critical thinking skills. Students read references in a variety of ways. Students in the RMS and GIRESiMCo groups read while jotting down important concepts. These concepts will be connected via a mind map. These activities were not used in the guided inquiry group or in the conventional group. We included reading in guided inquiry because earlier research has established a positive correlation between reading and cognitive achievement [37], and learning outcomes [39].

Sharing in GIRESiMCo learning refers to small group discussions in which participants debate the findings of investigations and information gleaned through reading. Prior to the class discussion, small group discussions were held. While sharing, each student also made brief notes about the results of the discussion. Since the GIRESiMCo learning model is developed on the constructivist and socio-cognitive theories, students were grouped into small groups of four to five students with diverse academic abilities. Discussions in small groups provide ample opportunity for each student to be involved in the investigation. All students in the group were responsible for tasks that had been determined by the group leader before the investigation began. The importance of sharing in small groups was highlighted in the research of Marcos et al. [37]. Based on research conducted on 60 students, peer support motivates students to share experiences and knowledge with each other. Similarly, Huang et al. found that arguing with peers in group discussions increases self-confidence [44] and supports learning achievement [39]. The discussion participants will become more flexible to exchange ideas and evaluate each other. Students who are quiet in their groups will get help because sharing can increase social interaction [45]. Science process skills developed at the sharing stage are communication skills. Peer support [37] has an indirect contribution to improving student learning outcomes.

Mind mapping was done after reading and group discussions. To create a mind map, students had to write down some keywords and symbols that relate to each other. Keywords and symbols were selected from the students' notes. The results showed that students in one group produced different mind maps even though they read the same sources and investigation reports. In this study, mind maps are essential because students can summarize many biological concepts into one display mind map image. Balim has revealed that mind maps are more effective for students to remember concepts [63]. An effective value of mind map that contributes to learning outcomes has been investigated by Hariyadi et al. which shows that 38.73% of mind maps contribute to learning outcomes [46]. Mind mapping is also useful for developing creativity [48]. This is because, in mind mapping, students are free to express their ideas through keywords, symbols, colors, and other components that make an image look attractive. Creativity in biology learning is needed, especially to solve problems during an investigation [37]. Mind mapping is a part of the cognitive dimension of "creating", which is the highest level in Bloom's Taxonomy.

5. Conclusions

As a novel guided inquiry learning model, GIRESiMCo integrates guided inquiry with reading, sharing, and mind mapping. This form of learning has been shown to scaffold students' scientific process skills and cognitive learning outcomes. This conclusion is based on data analysis of these two variables, which revealed that the GIRESiMCo group had higher SPS scores than the guided inquiry, RMS, and conventional groups. This increase

happens because of the GReSiMCo model's emphasis on student participation at all stages of learning. Students create their knowledge through teacher-guided group research. As a result, students gain authentic experience. This learning model is based on Jean Piaget's constructivism and Vigotsky's socio-cognitive theories, in which students construct their knowledge through group work in order to improve SPS and learning outcomes.

The findings of this study theoretically support the idea that guided inquiry in science education can scaffold SPS and student learning outcomes. By supplementing guided inquiry with reading, sharing, and mind mapping exercises, and so forming the GReSiMCo learning model, the hypothesis was demonstrated to be robust. This research is limited to the application of GReSiMCo for biology learning. It is recommended that future studies on GReSiMCo include teachers as an independent variable. Additionally, the GReSiMCo model of learning can be used in closely related areas, such as physics and chemistry.

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Appendix A

Science Process Skills Essay Test

1. Make a complete table showing the differences between prokaryotic and eukaryotic cells.
2. There are the names of cell organelles; endoplasmic reticulum, Golgi apparatus, ribosomes, lysosomes, peroxisomes, mitochondria, chloroplasts, vacuoles, centrioles, amyloplasts, and microtubules. From these organelles, make a grouping of plant and animal cells organelles.
3. One way to understand the bioprocesses in cells, especially cell reproduction, is by observing the mitosis process of onion roots. Therefore, a group of students prepares to observe it. Write down all the tools and materials that students will use for that activity!
4. Corn plant (*Zea mays*) is a plant that you often find in the garden. Think back to the plant and clearly describe the leaves.
5. An experiment shows that if the red blood cells are placed in a hypotonic solution, the blood cells swell because the fluid outside the cells will enter the blood cells. But what will happen if the blood cells are placed in a hypertonic solution? Write down your explanation along with pictures illustrations.

6. An experiment on plant tissue culture was conducted to determine the temperature effect on the plantlet height. Therefore, four groups of plantlets were prepared to be tested at four different temperature variations. The first group was at 10 °C, group two at 12 °C, group three at 14 °C, and group four at 18 °C. It was known in previous studies that at a temperature of 15 °C the plantlet height was longer than the plantlet height at 9 °C and the maximum temperature for plantlets was 23 °C. Create a hypothesis for the experiment.
7. One of the deadliest diseases in the world is cancer. Cancer attacks humans regardless of the socio-economic status of the community and is mostly suffered by adult humans. Cancer is closely related to the growth of cells in the human body. Make four questions related to this phenomenon.

Appendix B

Cognitive Learning Outcomes Questions

1. The cell membrane is semipermeable and serves to protect the cell cytoplasm. Explain how the mechanism of the membrane works according to this function.
2. When you watch a sports match, such as football or badminton, you will see that in a short rest period, athletes will consume certain drinks. If three types of drinks are provided, namely isotonic, hypotonic, and hypertonic, which type of drink is the most suitable for athletes to consume? Explain why you chose this drink.
3. Explain the function of the root hairs and root caps in plants.
4. One of the plants' tissues is the apical meristem. This tissue is closely related to the cells' totipotency. Explain why this tissue is indispensable in the tissue culture method.
5. In extreme drought conditions, the stems of the sweet orange plant (*Citrus sinensis*) and red spinach plant (*Amaranthus tricolor*) will show different conditions. The red spinach stems wilt and bends more quickly, while the sweet orange stem stays upright. Why does this phenomenon occur? Explain your answer by connecting this phenomenon to the structure of stem tissue.
6. In areas with high rainfall and cold temperatures (15–20 °C), you can find many plants with broad, thin leaves. If the plant is grown in an area hot temperatures (30–35 °C), explain what might be happening.
7. All tissues in our body (epithelial tissue, connective tissue, muscle tissue, and nervous tissue) work together to perform a biological process. Give an example of the cooperation of these four tissues in our body when doing an activity.
8. One day, Mrs. Rita (50 years old) was forced to walk to her office, which is one kilometer from her house. Walking is an activity that is rarely done because usually she always travels by car. The next day, she felt pain in her knee joint and calf muscles. In your opinion, is Mrs. Rita's complaint a disease of the motion system? What should she do in the future so that the complaint does not repeat itself?
9. When a part of our body is injured, the affected part will bleed. A few moments later, the blood that was previously flowing quickly will flow slowly, clot, and then stop. Explain why this phenomenon can occur.

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